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Dimensional Accuracy and Repeatability of 3D Printed Mould Inserts by DLP

S. Thorn¹, J.G. Bertelsen¹, M.M. Ribo¹, D. Li¹, F. Regi¹, A. Davoudinejad¹, Y. Zhang¹



¹Technical University of Denmark

silastjensen@outlook.com ; jacobgsb@gmail.com

Abstract

Mask projection vat photopolymerization technology provides a method for additive manufacturing (AM) of high resolution surface features. In the present project, the technology is used to generate injection moulding inserts containing a double-curved freeform surface with bi-directional reflectance patterns. Orienting these patterns 0° and 90° relative to the viewing direction generates surface contrast with “dark” and “bright” areas (Fig 1). This allows for incorporation of information barcodes in the polymer insert which subsequently replicates into every injection moulded part for e.g. enhanced product traceability, B2B information or end-user interaction at a significant reduction in lead-time compared to conventional tooling of inserts.

The barcode feature layer is manufactured onto a double-curved sinusoidal surface to simulate a complex surface of any given product. It has a peak-to-peak distance of 520µm and consists of 98.02µm x 98.02µm x 20µm cuboids. Bi-directional reflectance is generated by a triangular prism with a height of 17.28µm and slope of 10° on top of each cuboid (Fig 2). The project pushes the resolution limit of AM by utilising a custom built unit at DTU¹. A study into the effect of UV exposure on 1µm and 625nm layer thickness’ has been conducted with highest verified resolution achieved at the present moment to be voxel size of 7.54µm x 7.54µm x 4µm. The study showed that replication is highly dependent on the amount of UV exposure. Highest surface contrast was achieved with a radiant exposure $E = 12\text{mJ}/\text{cm}^2$ in troughs of the freeform surface however large areas of the surface were detached from midline to peak due to overexposure. Using $E = 2\text{mJ}/\text{cm}^2$ generates a uniformly covered reflectance surface with few defects. Metrological measurements of parts created with 1µm and 625nm layer thickness yield low surface roughness with Ra values ~50-100nm.

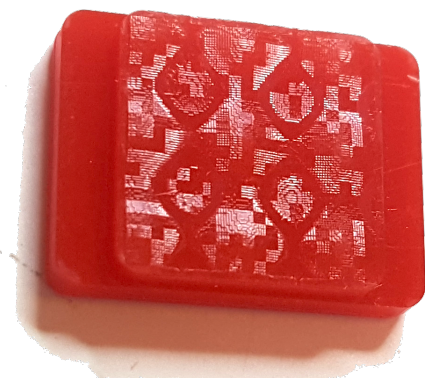


Figure 1 - Post-cured polymer insert with minor defects.

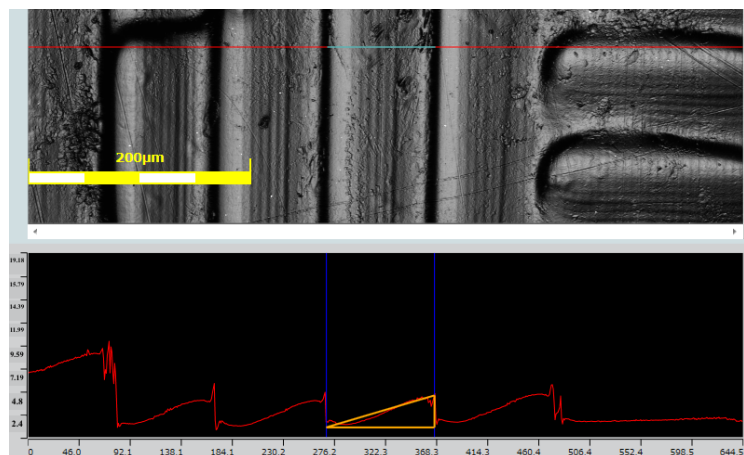


Figure 2 - Optical profilometry of reflectance patterns show low deviations compared to nominal dimension.